

FIG. 1A

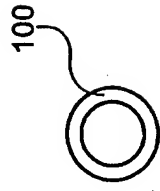


FIG. 1C

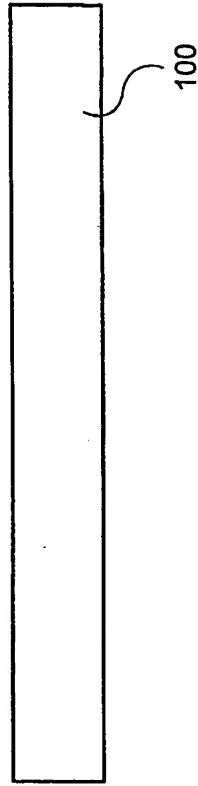


FIG. 1B

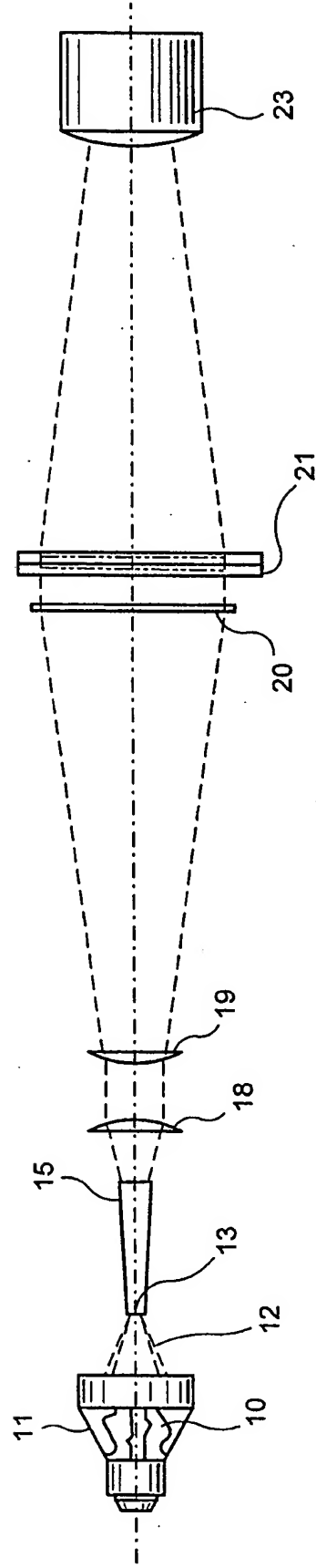


FIG. 2A

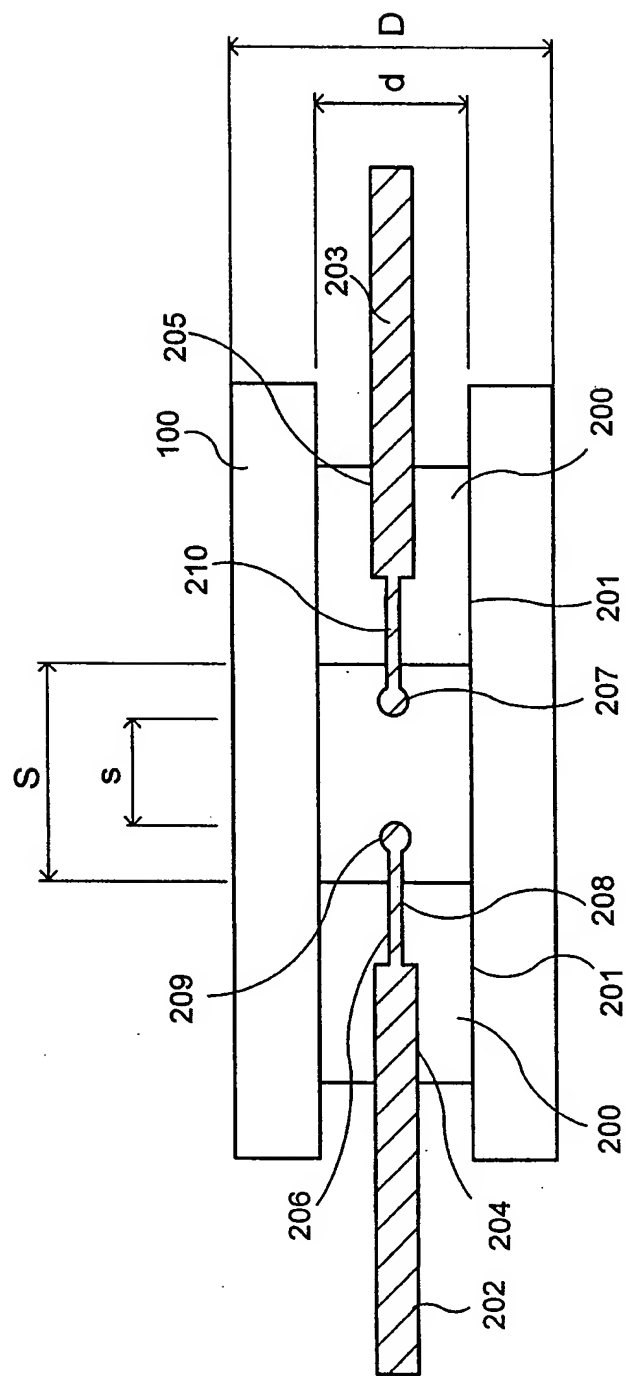


FIG. 2B

$$T_{\text{innerwallsapphire}_i} = \Delta T_2 + 273 \cdot K + T_{\text{outerwall}_i}$$

$$T_{\text{maxquartz}_i} = 1170 \cdot K$$

$$T_{\text{maxsapphire}_i} = 1400 \cdot K$$

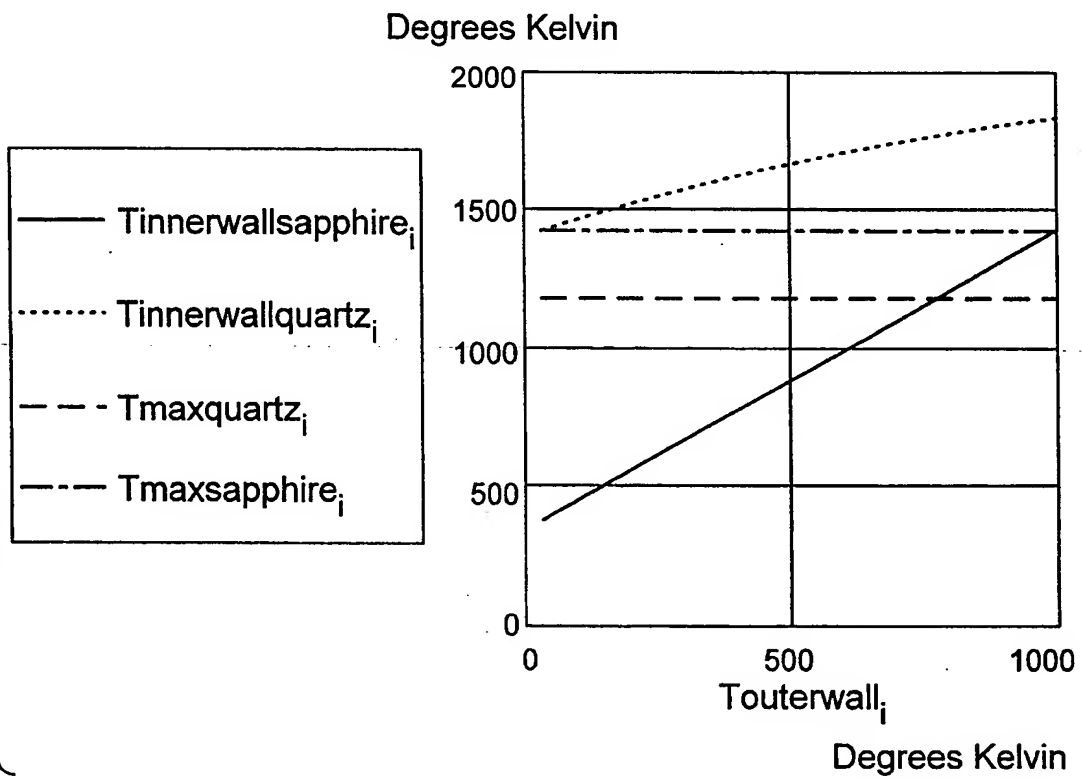


FIG. 3

Total Thermal Plus Hoop Stress on Bulb as a Fraction of Tensile Strength

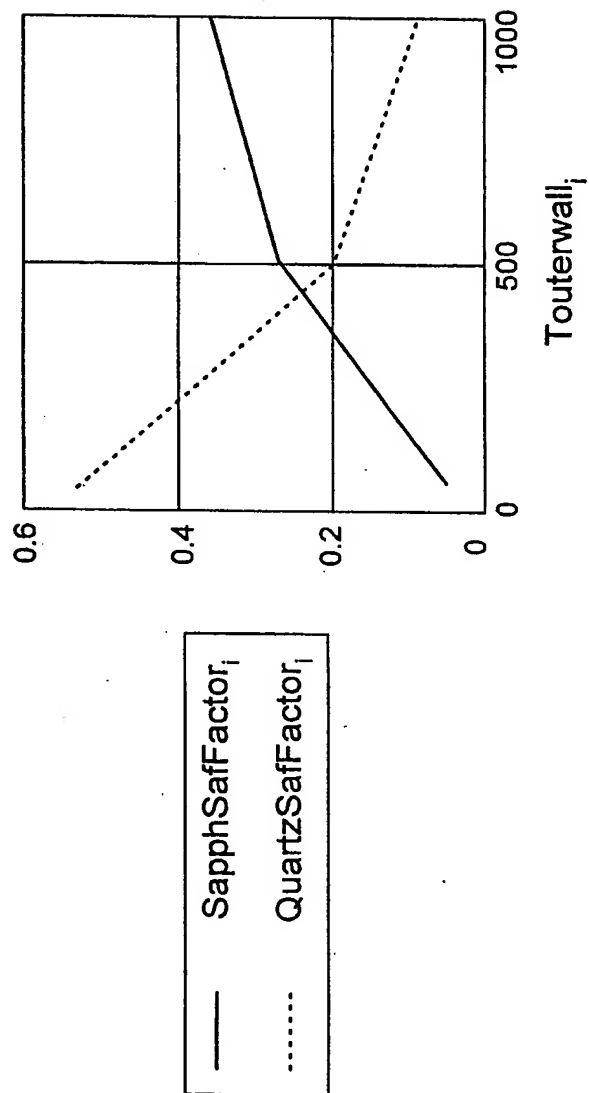


FIG. 4

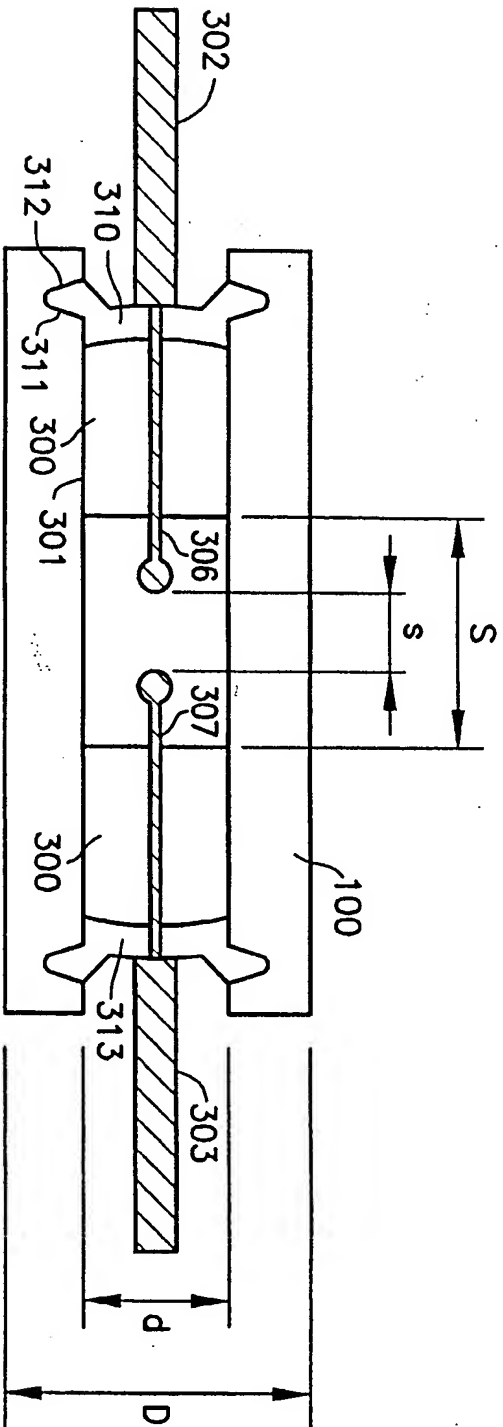


FIG. 5

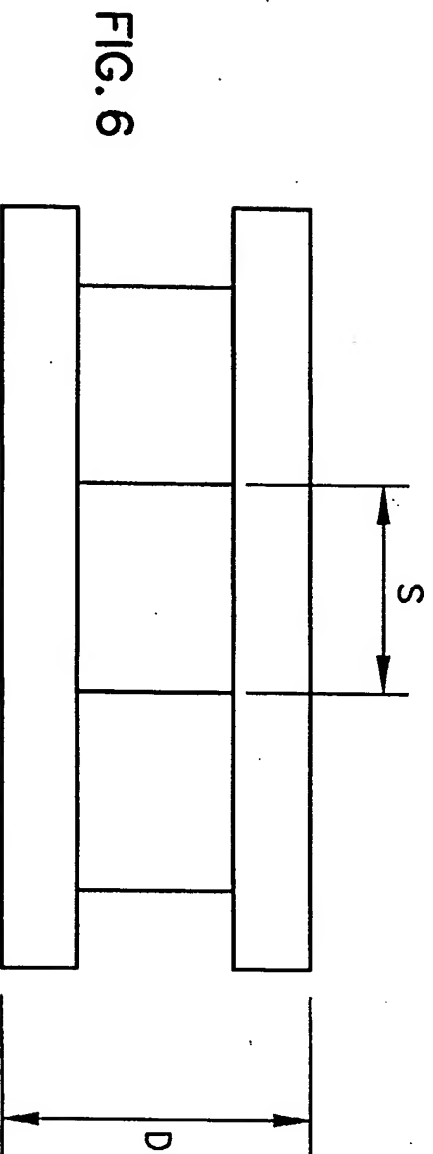


FIG. 6

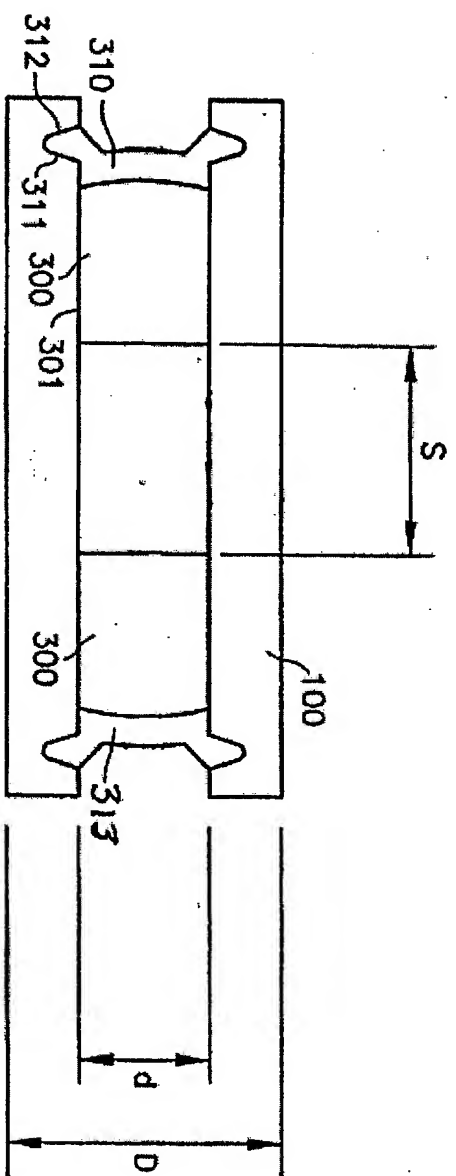


FIG. 7

## SAPPHIRE / QUARTZ COMPARISON

PROPERTIES	Units	Sapphire <sup>1</sup>	Alumina <sup>2</sup>	Quartz <sup>3</sup>
Softening Temperature	°C	2030	2000	1597
Maximum Operating Temperature	°C	1400	1400	900
Thermal Conductivity @ 600°K	W/cm°K	0.189	0.035	0.017
Expansion Coefficient @ 25-1100°C	m/m°K	$8.8 \times 10^{-5}$	$8.3 \times 10^{-6}$	$4.8 \times 10^{-7}$
Tensile Strength @ 25°C <sup>4</sup>	psi	155000	NA	7000
Max Transmittance 0.3-0.9µm (1.0mm wall)	1.0-100%	0.98 (clear)	0.84 (trans-luscent)	0.94 (clear)

<sup>1</sup> Single crystal alumina

<sup>2</sup> Poly-crystalline alumina

<sup>3</sup> Fused

<sup>4</sup> For tubes: Burst Pressure [ 2 X Wall Thickness X Tensile Strength @ Temp.] / Tube ID

TABLE 1

Temperature	Tensile Strength Sapphire	Tensile Strength Quartz
25°C	155000 psi	7000 psi
500°C	80000 psi	16500 psi
1000°C	73000 psi	24000 psi
1400°C	56000 psi	FAILURE

FOR TUBES

Burst Pressure -  $(2 \times \text{Wall Thickness} \times \text{Tensile Strength @ Temp}) / \text{ID}$

TABLE 2

THERMAL CONDUCTIVITY (W/CM·K)

TEMP (°C)	SAPPHIRE	QUARTZ
25	0.46	0.0138
800	0.17	0.018
1000	0.105	0.03

TABLE 3